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Modelling the Effect of Passenger/Freight Interference on Railway Costs

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MODELLING THE EFFECT OF PASSENGER/FREIGHT INTERFERENCE ON RAILWAY COSTS

BY

V. WEI

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15 Eddy St., 15th floor, Ottawa-Hull K1A 0N9

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Foreword

The division of Canada's railway systems into freight and passenger elements with full infrastructure ownership by the freight elements and the creation of a separate corporate entity to operate the railway passenger system presents economic circumstances not contemplated by the authors of the current railway costing process. This report explores an alternative or supplementary approach to the traditional methodology. Based on the concept of interference cost, a sum that would compensate the freight railway for incremental cost caused by the passenger operations is estimated.

It is concluded railway capacity and cost models can be used to estimate the cost of train interference. With feasibility established, a policy decision is necessary before the expense of developing an operational system could be justified. Such development would be of a much larger scale.

This Working Paper has been prepared by the Research Branch as a contribution to greater understanding of the complex issues that relate to railway passenger costing. The opinions expressed are those of the author and do not necessarily reflect the views of the Canadian Transport Commission.

Richard Lake
Executive Director
Research Branch

Canada

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The author, however, assumes full responsibility for the analysis and any errors that may be contained in this report.

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Chapter I

INTRODUCTION

1.1 Objective

The purpose of this study is to investigate the potential application of railway capacity and cost models to the estimation of incremental costs incurred by interaction between passenger and freight trains. In addition to the use of existing railway models, this study also develops computer models to aid in computations of the interference cost. These models are designed to examine the route specific impact on the cost of freight service of different options for rail passenger service, including the removal of passenger trains, and incremental expansion of passenger train service.

Both the cost and the capacity implications of running freight and passenger trains on the same track have been subjects of much interest in various railway studies. However, they are usually dealt with separately, with costing studies examining passenger service costing methodologies and railway capacity models trying to determine the impact of passenger trains on the average train trip time and required improvement in existing plant. The present study attempts to combine the methodologies that have been developed in these two fields to examine delay-induced increases in costs of freight services at different levels of passenger traffic.

The concept of interference cost associated with passenger trains is one of current importance. Since VIA took over the railway passenger operations in Canada, freight and passenger services have become two separate products offered by different

firms rather than common products produced by the same firm. Thus, the historical shared-cost method of allocating indirect costs and overhead may have to be challenged. The problem involves the determination of costs that are representative of the capacity penalty imposed by passenger trains on the traffic of the other railway companies.

The interference cost estimate can also be used in cost/benefit analysis of new facility planning. The reduced interference costs would be the potential benefit of plant expansion and investment.

1.2 Scope

In the following chapter, an overview of capacity problems and cost issues will be given in the context of providing a background for the interference analysis.

The third chapter investigates the impact of passenger trains on freight train operations by comparing train trip time or train delays between the base case which represents actual railway operations in 1983 and alternative cases which include on the one hand, the removal of passenger trains and on the other hand, increasing passenger trains until the limit of capacity of the existing plant is met. The interference analysis is applied to four railway segments in Western Canada including two CN and two CP line segments.

Two different approaches are used to estimate the increased operating and ownership costs resulting from interference train delay in freight services. The effect of train delays on rolling stock requirements and productivity is also examined. In Chapter IV, the costing methodologies are discussed in detail.

The results of the cost models are analyzed and compared in Chapter V. Finally, the study is concluded and further analysis recommended in Chapter VI.

1.3 Data and Methodology

The 1983 financial and operating data of Canadian National and Canadian Pacific Railways were obtained from Statistics Canada Report 52-215, Railway Financial and Traffic Statistics. These data, supplemented by CN and CP operating statistics submitted to the Canadian Transport Commission, are used in capacity analysis and cost calculations.

The average time of freight train trips with varying daily frequencies of passenger trains are calculated using the railway capacity model developed by the Canadian Institute of Guided Ground Transport (CIGGT). The increased train delays in terms of train hours and car days are then calculated by procedures built into the worksheet of LOTUS/1-2-3 on IBM Personal Computers.

Two cost models are also developed on the IBM PC. One uses the unit cost approach where system unit costs of affected railway service units are calculated and applied to estimate increased costs due to train delay. The other adopts the method of the World Bank RAIL Model modified to fit the interference cost analysis.

CHAPTER II

BACKGROUND

2.1 Right-of-Way and Train Priority

A railroad right-of-way is the land or real estate on which the roadbed and other structures and facilities are constructed. Running high speed passenger trains and long, slow freight trains on the same right-of-way create problems that affect railway line capacity.

Passenger trains on the transcontinental and corridor services generally receive "preferred handling" which means they are given higher priority than freight trains. Train priority is vital to passenger train scheduling in competition with other passenger transportation modes.

Train speed and train priority are the two most important factors for capacity analysis. Non-uniform train speed creates meets and overtakes and interference delays; whereas train priority has direct impact on the length of delays of a particular type of train. Other factors, such as track configuration, traffic levels, work programs and the signal system also affect interference delays. For instance, where a railway segment is double tracked, and full two-way central traffic control is in operation, the effect of high speed and priority passenger trains on cost of freight service may be negligible; on the other hand, in a single tracked rail segment, the interference cost may be high.

2.2 Railway Line Capacity Analysis

In this study, the CIGGT's LINE Model is used to investigate the impact of passenger trains on the capacity of the railway line to provide freight train services. The impact is measured by train delays due to interference between passenger and freight trains. As detailed descriptions of the model can be found in a number of existing studies (1,2,3), only a brief overview, concentrating on its application to the passenger/freight interference analysis is given below.

LINE is an analytical model that calculates the expected transit time for each train type at given traffic levels on a specific line segment. The expected transit time is estimated from the free running time plus the interference delays. The length of interference delay is influenced by the frequency of meets and overtakes, which is, in turn, affected by a number of factors in railway systems and operations. For instance, the model uses different delay functions to account for different track configurations, including grade, curvature and single or double trackages, as well as for different signal systems.

The following is a list of factors that affect interference delay; correspondingly, a list of input requirements to the model is also provided.

	Factors Affecting Train Delays	Inputs to the LINE Model
1.	Traffic level and mix	-Trains per day by train class in each direction.
2.	Track configuration	-Single or double trackage, mileages.
3.	Train speed	-Free running speed for each type of train in each direction.

4.	Signal System	-e.g. Automatic Train Control (ATC), Centralized Train Control (CTC). Number of intermediate signals, etc.
5.	Train priority	-Train priority matrix indicating the relative priority between a pair of trains.
6.	Switch time	-Switch delays for each priority class.
7.	Safe stopping distance	-Minimum headway between trains.
8.	Changes in traffic level	-The class of trains for which traffic can be increased for capacity measurements.

The model allows the traffic of one class of train to increase. In this analysis, the daily frequencies of freight trains or interference between freight trains are held constant while the number of passenger trains per day is varied. The base case is with two passenger trains per day (one in each direction). The alternative cases include the removal of passenger trains and the incremental increase in the number of passenger trains, two at a time (one in each direction) until the theoretical capacity is reached.

The theoretical capacity is determined by the model. The model estimates train transit times and interference delays based on overtakes and meets at each incremental level of traffic and terminates once all measures exceed their feasibility limits. However, the traffic level where mathematical infeasibility results is usually close to the absolute physical capacity (bottleneck) and this can be well above the practical operating capacity of a line.

At the start of the analysis, it is necessary to define line capacity. Depending on the constraints set by the analyst, capacity can be defined in various ways. Generally, practical capacity is determined by the amount of delay to equipment and crew that a carrier is willing to tolerate; for instance, in the recent Joint Track Usage

Study, practical capacity is defined by an average of 50-60 minutes of meet delay per 100 miles as a basis for new facility planning (4).

For the purposes of this study, the capacity is considered reached if any of the following conditions hold:

1. Average total delay reached 50% of free running time.

2. Average total delay for any class of train reached 67% of that class' free running time.

3. Any train or class of train had a transit time that exceeded 10 hours. (5)

In its outputs, the model indicates where this practical capacity is reached. However, it continues to add passenger trains until the mathematical limit is reached. While any traffic level above the practical capacity defined above may not be realistic, it is useful in deriving a theoretical delay curve in the capacity analysis. However, in the interference cost analysis, only the traffic levels within the capacity defined above are included.

The outputs of the LINE model include:

(1) an average delay matrix which shows expected delay times between each pair of train types.

(2) a table of free running time and speed by train types in each direction.

(3) a table of "normalized" transit times by train types and traffic levels. The normalized transit time represents the ratio between present operating time and free running time for each train class.

These outputs are used to calculate delays in the interference analysis presented in Chapter 3.

2.3 Cost Issues

Generally, the interference cost analysis is associated with increased railway operating and ownership costs due to train delays. The concept of interference cost is useful in cost/benefit analysis where the cost of capacity expansion to eliminate interference can be compared with the benefit of reduction in operating costs. In other words, the estimate of increases in operating and ownership costs due to train delay may be used as a justification for new facility planning.

In this study, the interference cost is defined specifically as increased costs in freight operation resulting from the capacity penalty imposed by passenger trains operating on the common trackage. Thus, from the point of view of the railways owning the right-of-way, the interference costs can be considered as avoidable costs with the

removal of passenger trains; whereas, from the point of view of passenger service, the concept of interference cost may be developed to provide an alternative way of calculating the indirect costs of service purchased from other railways.

Over the past decade, the traditional method of railway costing in Canada had undergone extensive scrutinies (6) and was generally considered as satisfactory in costing individual train services. However, the separation of the rail passenger service from the freight companies in the late 1970's makred a new era in Canadian railroad industry. Under the new circumstances, a review of the present railway costing system has become exigent.

Without its own right-of-way, VIA contracts for the use of rail line facilities of other railways. The railways charge VIA by the concept of avoidable costs. Based on costing methodology, the avoidable costs can be divided into two categories: one is the specific costs which are determined by the method of direct assignment; the other consists of indirect costs and overheads that are determined by the unit cost approach where unit costs are determined by either regression analysis or direct analysis. On average, 70% of the railway passenger charges is based on specific costs and 30% is determined by unit cost methods. (7)

In the unit cost approach, expenses common to passenger and freight services are costed together and prorated to each service based on output units, such as train miles and gross ton-miles. This implies that for each service or output unit, both passenger and freight services incur the cost equally. This shared-cost concept is adopted under Railway Costing Regulation R-6313. In 1983, the railways' charges to VIA amounted to $380 million, thus, VIA shared roughly $114 million of indirect and overhead costs with railways. (8)

Although passenger/freight interference currently exists in railway operations, the traditional railway costing methodology does not specifically deal with capacity issues nor interference costs. Rather, these costs are hidden costs included in annual actual expenditures, and they are accounted for in the calculation of system average unit costs. The costing method leaves VIA little flexibility in the negotiation of railways' charges.

The applicability of the concept of interference cost to railway costing was examined by M.E. Kieran and J.M. Mugnet of Peat, Marwick and Partners in 1977. (9) In their paper entitled "Passenger Trains and Rail Traffic Interference", Kieran and Mugnet used simulation models to determine the amount of fixed plant required to accommodate a specific service, particularly, the passenger service. They consider both the interference cost concept and the base-increment costing approach as alternatives to the traditional shared-cost approach in the determination of railway costs that are representative of the capacity used by passenger trains. However, the paper only gives a brief discussion of the cost issues and the authors reach no general conclusion since they claim that it would be necessary to carry out more simulation cases to make complete statements about the cost of freight/passenger interference.

In fact, the significance of interference delay and cost varies in each rail segment depending on the route specific railway line capacity and traffic density. A system wide application of the interference cost method is difficult. However, it may be possible to develop potential application in costing of specific passenger services, for instance, the corridor, regional or remote passenger services.

The present study concentrates on developing methodologies for estimating interference costs rather than their application. It takes two different approaches to the

estimation of interference costs. The first adopts the railway unit cost method where the cost items and service units affected by train delays are identified and interference costs are estimated by multiplying unit costs by service units. The second approach first analyzes the effect of train delay on the rolling stock requirement and productivity, then estimates interference costs; the World Bank's rail model is modified to aid in this analysis. These methodologies will be discussed in detail in Chapter IV.

CHAPTER III

INTERFERENCE ANALYSIS

The interference analysis is applied to four railway subdivisions: CP Thompson and Cascade subdivisions and CN Ashcroft and Yale subdivisions. These subdivisions are located between Kamloops and Mission City in British Columbia. They were chosen because data required for inputs to capacity models had already been collected for another ongoing CTC research project (10).

The interference analysis involves estimating service or output units that are affected by train delays. Two steps are taken: first, the railway line capacity model is used to calculate train delays in terms of train hours under different levels of passenger traffic, and second a computer procedure is set up to compute other affected services or output units associated with delays in train hours.

3.1 Analytical Results from Railway Line Capacity Models

Essentially two outputs of the capacity model are used to calculate train delays: the first is a table of free running time and speed by train types in each direction, and the second a table of "normalized" transit times by train types and incremental passenger train traffic levels.

3.1.1 CN Ashcroft and Yale Subdivisions

CN Ashcroft subdivision runs between Kamloops and Boston Bar. It is 125.5 miles in length. The division includes 17 single track and 2 double track sections. The

signal system is CTC. Model (capacity) outputs for this subdivision are shown in Table 3.1.

Table 3.1 contains two parts. The first part shows the number of trains per day by each class of train, free running time, transit time with interference (congested time) and related train speeds. The congested time is calculated from the free running time plus the interference delays. In the case of no passenger trains, the congested time includes delays due to interaction between freight trains.

In the second part of Table 3.1, the normalized transit times at different passenger traffic levels are presented for each class of trains. The first column shows the number of passenger trains per day in each direction in each alternative case. Two passenger trains (one in each direction) are systematically added and changes in transit times are calculated accordingly until mathematical infeasibility is reached; the columns numbered 1 to 10 represent the five classes of trains in each direction as listed in the first part of the Table.

The traffic level in the base case is 19.2 trains per day, including a passenger train travelling daily in each direction. The congested time which is estimated by the capacity model may be different then the actual operating schedules of CN in 1983 because the latter include work program delays. No adjustment is made to correct this discrepancy because in this study we are interested only in the interaction between passenger and freight services, and not in the work crew induced delays.

The capacity model also indicates the traffic level at which point the line's bottleneck is reached, and the point at which the delay time exceeds constraints set up for the model. In practice, the traffic level should not exceed the latter.

Table 3.1

EFFECT OF PASSENGER TRAINS ON FREIGHT TRAIN TRANSIT TIMES
FROM CIGGT CAPACITY MODEL

CN ASHCROFT (Kamloops - Boston Bar)

I . FREIGHT TRAIN TIME AND SPEED - WITHOUT PASSENGER TRAINS

Train Code	Direction*	Type of Trains	Trains per day	Free Running Time		With Interference	
				Time	Speed	Time	Speed
1	IB	SLOW FREIGHT	3.4	4:17	29.3	5:14	23.9
2	IB	SOLID/UNIT	3.7	4:12	29.9	4:57	25.3
3	IB	FAST FREIGHT	1.4	4:10	30.1	4:45	26.4
4	IB	LOCAL	.01	4:05	30.7	4:58	25.2
5	IB	PASSENGER	.0	3:49	32.9	3:59	31.4
6	OB	PASSENGER	.0	3:43	33.8	3:50	32.6
7	OB	LOCAL	.02	4:02	31.1	4:51	25.9
8	OB	FAST FREIGHT	1.8	4:09	30.2	4:34	27.4
9	OB	SOLID/UNIT	3.8	4:20	29.0	5:04	24.7
10	OB	SLOW FREIGHT	3.1	4:25	28.4	5:17	23.7

II. WITH PASSENGER TRAINS - TRANSIT TIME NORMALIZED TO FREE RUNNING TIME

Passenger** Trains/Day	Train Code									
	1	2	3	4	5	6	7	8	9	10
Free Time	4:17	4:12	4:10	4:05	3:49	3:43	4:02	4:09	4:20	4:25
1	1.27	1.22	1.18	1.26	1.06	1.04	1.25	1.13	1.22	1.25
2	1.32	1.27	1.22	1.31	1.08	1.05	1.30	1.16	1.27	1.30
3	1.38	1.32	1.26	1.36	1.09	1.06	1.35	1.20	1.32	1.37
4	1.45	1.38	1.31	1.41	1.11	1.08	1.41	1.23	1.38	1.43
5	1.52	1.44	1.37	1.47	1.12	1.10	1.47	1.27	1.44	1.51
6	1.59	1.50	1.42	1.54	1.14	1.12	1.54	1.31	1.51	1.59
7	1.68	1.58	1.49	1.61	1.16	1.14	1.61	1.36	1.59	1.68
8	1.78	1.66	1.56	1.69	1.18	1.17	1.69	1.40	1.67	1.79
9	1.89	1.76	1.65	1.78	1.20	1.22	1.78	1.46	1.77	1.91
10	2.02	1.88	1.75	1.89	1.23	1.28	1.89	1.53	1.89	2.05
11	2.16	2.01	1.87	2.01	1.28	1.36	2.00	1.61	2.02	2.22
12	2.33	2.16	2.01	2.16	1.35	1.48	2.13	1.70	2.17	2.41
13	2.53	2.33	2.17	2.32	1.45	1.63	2.27	1.78	2.33	2.63
14	2.79	2.57	2.37	2.53	1.58	1.85	2.41	1.86	2.51	2.88
15	3.12	2.88	2.65	2.80	1.78	2.26	2.51	1.93	2.64	3.10
16***	3.98	3.72	3.42	3.52	2.39	3.03	2.75	2.23	2.72	2.90
17	5.22	4.92	4.51	4.57	3.29	4.15	3.36	2.67	3.32	3.57
18	6.97	6.61	6.03	6.03	4.67	5.97	4.29	3.36	4.25	4.60

CAPACITIES

Bottleneck Section (8):	19.8	IB	and	19.8	OB Passenger trains per day
Mathematical Infeasibility:	18.0	IB	and	18.0	OB Passenger trains per day
Time Exceeds Pct. of Base:	7.0	IB	and	7.0	OB Passenger trains per day

*IB = Eastbound, OB = Westbound.

**Number of passenger trains in each direction.

***In some cases, the model may change automatically the priority of certain classes of trains in order to accommodate total traffic within the capacity. When this occurs, some train classes may benefit at the capacity penalty of others.

CN Yale subdivision covers rail segments between Boston Bar and Hydro. It is 101.7 miles long and consists of 12 single track and 2 double track sections. The signal system is CTC.

The Yale segment is a continuation of the Ashcroft segment, the same traffic goes through both subdivisions, with only a slight difference in local traffic. However, it was considered necessary to run the line capacity model separately for the two divisions because the train stops and crew change points set up between the two subdivisions would have an impact on the average train speeds. The outputs of capacity models for the Yale subdivision are shown in Table 3.2.

3.1.2 CP Thompson and Cascade Subdivision

The CP Thompson subdivision covers the railway segment from Kamloops to North Bend. It includes 15 single track and 2 double track sections. Total distance is 121.5 miles. The signal system is CTC. Train transit times at different passenger traffic levels are presented in Table 3.3.

The CP Cascade Subdivision covers the line segment between North Bend and Mission City. It includes 7 single track and 5 double track sections with a total distance of 87.3 miles. Signal system is CTC.

Track configurations in the Thompson and Cascade segments are somewhat different; in the Thompson Subdivision only 9.5% of the line is double tracked while in the Cascade subdivision, about 41% of the line is double tracked. The model outputs of the Cascade subdivision are presented in Table 3.4.

Table 3.2

EFFECT OF PASSENGER TRAINS ON FREIGHT TRAIN TRANSIT TIMES
FROM CIGGT CAPACITY MODEL

CN YALE (Boston Bar - Hydro)

I . FREIGHT TRAIN TIME AND SPEED - WITHOUT PASSENGER TRAINS

Train Code	Direction	Type of Trains	Trains per day	Free Running Time		With Interference	
				Time	Speed	Time	Speed
1	IB	SLOW FREIGHT	3.4	3:00	33.9	3:41	27.6
2	IB	SOLID/UNIT	3.7	2:54	35.1	3:26	29.6
3	IB	FAST FREIGHT	1.4	2:52	35.5	3:08	32.5
4	IB	LOCAL	.2	2:46	36.8	3:28	29.2
5	IB	PASSENGER	.0	2:19	43.9	2:26	41.6
6	OB	PASSENGER	.0	2:19	43.9	2:25	42.0
7	OB	LOCAL	.2	2:50	35.9	3:28	29.2
8	OB	FAST FREIGHT	1.8	2:53	35.3	3:04	33.0
9	OB	SOLID/UNIT	3.8	3:03	33.3	3:38	28.0
10	OB	SLOW FREIGHT	3.1	3: 0	32.5	3:40	27.6

II. WITH PASSENGER TRAINS - TRANSIT TIME NORMALIZED TO FREE RUNNING TIME

Passenger* Trains/Day	Train Code									
	1	2	3	4	5	6	7	8	9	10
Free Time	3: 0	2:54	2:52	2:46	2:19	2:19	2:50	2:53	3:03	3:08
1	1.28	1.23	1.12	1.31	1.07	1.05	1.28	1.09	1.24	1.22
2	1.34	1.28	1.15	1.37	1.08	1.06	1.33	1.11	1.29	1.26
3	1.40	1.33	1.17	1.43	1.10	1.08	1.39	1.13	1.35	1.31
4	1.46	1.39	1.21	1.50	1.12	1.09	1.46	1.15	1.42	1.37
5	1.54	1.45	1.24	1.58	1.13	1.11	1.53	1.18	1.49	1.43
6	1.62	1.52	1.27	1.67	1.15	1.12	1.62	1.20	1.57	1.49
7	1.71	1.60	1.31	1.76	1.17	1.15	1.71	1.23	1.66	1.56
8	1.81	1.69	1.35	1.87	1.19	1.17	1.81	1.25	1.76	1.64
9	1.92	1.79	1.40	1.99	1.21	1.21	1.92	1.29	1.88	1.74
10	2.06	1.91	1.45	2.13	1.23	1.26	2.05	1.33	2.03	1.84
11	2.21	2.05	1.51	2.29	1.27	1.32	2.21	1.38	2.19	1.97
12	2.38	2.21	1.58	2.48	1.33	1.40	2.38	1.43	2.39	2.11
13	2.59	2.39	1.66	2.70	1.40	1.50	2.58	1.49	2.62	2.27
14	2.84	2.62	1.75	2.96	1.49	1.64	2.82	1.54	2.90	2.44
15	3.15	2.89	1.85	3.29	1.61	1.82	3.08	1.60	3.23	2.65
16	3.54	3.24	1.98	3.70	1.76	2.09	3.37	1.64	3.61	2.86
17	4.12	3.77	2.17	4.32	2.02	2.65	3.58	1.77	3.92	3.00
18	5.65	5.29	2.80	5.98	3.01	5.38	3.52	2.07	3.48	3.06
19	7.24	6.79	3.31	7.70	3.88	7.11	4.26	2.39	4.23	3.66

CAPACITIES

Bottleneck Section (8):	24.4	IB	and	24.4	OB Passenger trains per day
Mathematical Infeasibility:	19.0	IB	and	19.0	OB Passenger trains per day
Time Exceeds Pct. of Base:	6.0	IB	and	6.0	OB Passenger trains per day

* Number of passenger trains in each direction.

Table 3.3

EFFECT OF PASSENGER TRAINS ON FREIGHT TRAIN TRANSIT TIMES
FROM CIGGT CAPACITY MODEL

CP THOMPSON (Kamploops - North Bend)

I . FREIGHT TRAIN TIME AND SPEED - WITHOUT PASSENGER TRAINS

Train Code	Direction	Type of Trains	Trains per day	Free Running Time		With Interference	
				Time	Speed	Time	Speed
1	IB	SOLID/UNIT	3.7	4:00	30.4	5:01	24.2
2	IB	SLOW FREIGHT	5.3	3:55	31.0	4:34	26.6
3	IB	FAST FREIGHT	1.8	3:48	32.0	4:22	27.8
4	IB	LOCAL	.4	3:41	33.0	4:24	27.6
5	IB	PASSENGER	.0	3:31	34.5	3:42	32.8
6	OB	PASSENGER	.0	3:33	34.2	3:41	32.9
7	OB	LOCAL	.3	3:47	32.1	4:23	27.7
8	OB	FAST FREIGHT	3.4	3:50	31.7	4:15	28.6
9	OB	SLOW FREIGHT	3.2	4:02	30.1	4:42	25.8
10	OB	SOLID/UNIT	3.4	4:12	28.9	5:05	23.9

II. WITH PASSENGER TRAINS - TRANSIT TIME NORMALIZED TO FREE RUNNING TIME

Passenger Trains/Day	Train Code									
	1	2	3	4	5	6	7	8	9	10
Free Time	4:00	3:55	3:48	3:41	3:31	3:33	3:47	3:50	4:02	4:12
1	1.30	1.20	1.19	1.23	1.07	1.05	1.19	1.14	1.20	1.26
2	1.36	1.24	1.22	1.26	1.08	1.06	1.22	1.16	1.24	1.30
3	1.42	1.28	1.26	1.30	1.10	1.07	1.25	1.19	1.28	1.36
4	1.48	1.32	1.31	1.34	1.11	1.08	1.28	1.22	1.33	1.42
5	1.55	1.36	1.35	1.38	1.13	1.10	1.32	1.26	1.38	1.48
6	1.63	1.41	1.40	1.42	1.15	1.12	1.36	1.29	1.43	1.55
7	1.72	1.47	1.46	1.47	1.17	1.15	1.40	1.33	1.49	1.63
8	1.82	1.53	1.52	1.52	1.18	1.18	1.44	1.37	1.55	1.71
9	1.94	1.60	1.60	1.58	1.21	1.22	1.49	1.42	1.62	1.81
10	2.08	1.68	1.69	1.65	1.24	1.29	1.54	1.48	1.70	1.93
11	2.24	1.77	1.79	1.73	1.30	1.38	1.60	1.54	1.78	2.05
12	2.43	1.87	1.90	1.82	1.37	1.50	1.66	1.61	1.88	2.19
13	2.66	1.99	2.04	1.92	1.47	1.66	1.72	1.67	1.97	2.35
14	2.94	2.13	2.21	2.04	1.61	1.91	1.77	1.72	2.06	2.50
15	3.36	2.34	2.45	2.21	1.84	2.39	1.89	1.86	2.05	2.56
16	4.61	3.03	3.25	2.80	2.59	4.55	2.19	2.17	2.43	2.70
17	5.79	3.58	3.91	3.27	3.32	5.95	2.50	2.51	2.81	3.15
18	7.93	4.53	5.04	4.21	4.70	8.59	3.06	3.11	3.50	3.97

CAPACITIES

Bottleneck Section (14):	19.7	IB	and	19.7	OB	Passenger trains per day
Mathematical Infeasibility:	18.0	IB	and	18.0	OB	Passenger trains per day
Time Exceeds Pct. of Base:	6.0	IB	and	6.0	OB	Passenger trains per day

Table 3.4

EFFECT OF PASSENGER TRAINS ON FREIGHT TRAIN TRANSIT TIMES
FROM CIGGT CAPACITY MODEL

CP CASCADE (North Bend - Mission)

I . FREIGHT TRAIN TIME AND SPEED - WITHOUT PASSENGER TRAINS

Train Code	Direction	Type of Trains	Trains per day	Free Running Time		With Interference	
				Time	Speed	Time	Speed
1	IB	SOLID/UNIT	3.7	2:39	32.9	3:15	26.8
2	IB	SLOW FREIGHT	5.3	2:36	33.6	2:59	29.2
3	IB	FAST FREIGHT	1.8	2:34	34.0	2:54	30.0
4	IB	LOCAL	.3	2:30	34.9	2:55	29.8
5	IB	PASSENGER	.0	2:20	37.4	2:27	35.5
6	OB	PASSENGER	.0	2:18	38.0	2:23	36.4
7	OB	LOCAL	.3	2:30	34.9	2:52	30.3
8	OB	FAST FREIGHT	3.4	2:34	34.0	2:49	30.8
9	OB	SLOW FREIGHT	3.2	2:38	33.2	3:02	28.7
10	OB	SOLID/UNIT	3.4	2:49	31.0	3:22	25.9

II. WITH PASSENGER TRAINS - TRANSIT TIME NORMALIZED TO FREE RUNNING TIME

Passenger Trains/Day	Train Code									
	1	2	3	4	5	6	7	8	9	10
Free Time	2:39	2:36	2:34	2:30	2:20	2:18	2:30	2:34	2:38	2:49
1	1.27	1.18	1.17	1.20	1.07	1.05	1.18	1.13	1.19	1.24
2	1.32	1.21	1.20	1.23	1.08	1.06	1.21	1.15	1.22	1.28
3	1.37	1.25	1.24	1.26	1.09	1.07	1.24	1.18	1.26	1.33
4	1.43	1.28	1.28	1.30	1.11	1.08	1.27	1.21	1.30	1.38
5	1.49	1.32	1.32	1.33	1.12	1.09	1.31	1.24	1.35	1.44
6	1.56	1.36	1.36	1.37	1.13	1.11	1.34	1.27	1.39	1.50
7	1.63	1.41	1.41	1.42	1.15	1.13	1.38	1.31	1.44	1.57
8	1.72	1.46	1.47	1.46	1.17	1.16	1.42	1.35	1.50	1.64
9	1.81	1.52	1.53	1.51	1.19	1.19	1.47	1.39	1.56	1.72
10	1.92	1.58	1.61	1.57	1.21	1.24	1.51	1.44	1.63	1.81
11	2.05	1.65	1.69	1.63	1.25	1.30	1.56	1.49	1.70	1.91
12	2.19	1.73	1.78	1.70	1.29	1.37	1.62	1.55	1.78	2.02
13	2.35	1.81	1.89	1.78	1.35	1.47	1.67	1.60	1.86	2.14
14	2.54	1.91	2.00	1.86	1.42	1.59	1.72	1.65	1.94	2.27
15	2.79	2.02	2.13	1.95	1.51	1.74	1.77	1.69	2.02	2.42
16	3.11	2.15	2.30	2.06	1.62	1.96	1.80	1.71	2.09	2.57
17	3.56	2.33	2.53	2.21	1.78	2.36	1.91	1.83	2.05	2.61
18	4.47	2.71	3.02	2.53	2.15	3.47	2.09	2.01	2.27	2.48
19	5.91	3.25	3.71	2.97	2.69	4.92	2.35	2.26	2.58	2.83
20	7.72	3.75	4.38	3.37	3.26	6.10	2.64	2.55	2.94	3.24
21	11.10	4.50	5.41	3.97	4.16	7.99	3.12	3.01	3.51	3.89

CAPACITIES

Bottleneck Section (2):	15.8	IB	and	15.8	OB Passenger trains per day
Mathematical Infeasibility:	21.0	IB	and	21.0	OB Passenger trains per day
Time Exceeds Pct. of Base:	7.0	IB	and	7.0	OB Passenger trains per day

However, once the transit times and train delays are calculated, the delay times of the two subdivisions are added up for further interference and cost analysis.

3.2 Analysis of Train Delays

Interference delays are reflected in the changes in transit times of freight trains at different passenger service levels. The interference delays represent the first order delay resulting from more frequent meets and overtakes and the needs to start, stop and slow down trains in a trip. A second order delay may also be generated due to increased track maintenance times at higher traffic levels. Work program slow orders may in turn affect first order delays. However, in this study, only the first order delay is estimated.

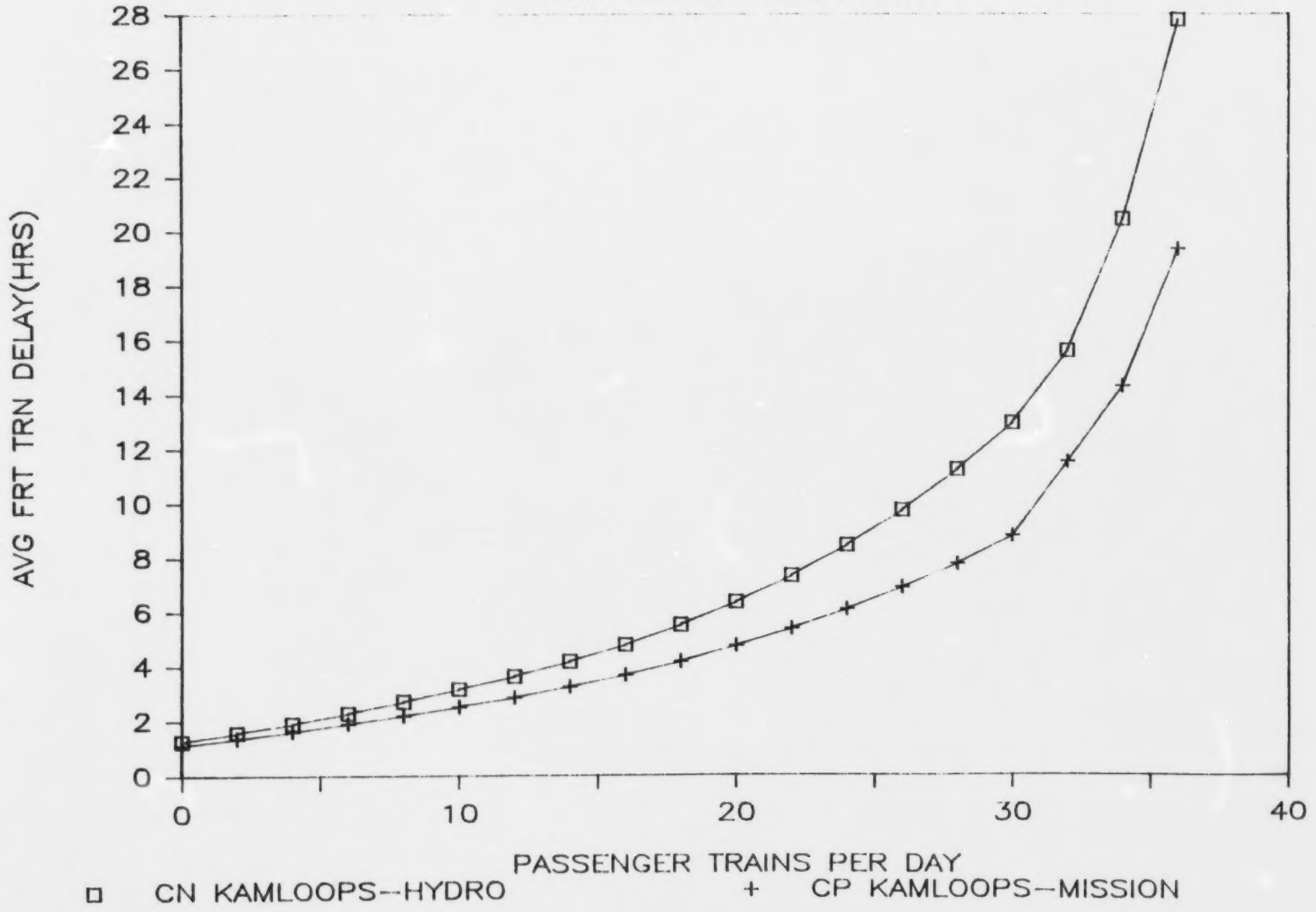
Figure 3.1 shows the average freight train delay times (in hours) in relation to the number of passenger trains per day for the CP Kamloops-Mission City and CN Kamloops-Hydro routes. The average delay times represent delays of different freight train types weighted by their daily frequencies. The points where the delay curves intercept the vertical axis represent the delays due to interaction between freight trains.

Changes in average freight train trip times are multiplied by the total number of freight trains per day and by 365 days to obtain the increased train hours in a year for a given traffic level compared to the base case.

Delays in train hours can be directly converted to car-days and locomotive hours based on the average number of cars and locomotives per train respectively. However, as each type of freight car has different ownership costs, it is necessary to associate types of freight trains to types of cars in estimating car days and car day

FIGURE 3.1

INTERFERENCE TRAIN DELAY



related costs. The same problem occurs in estimating locomotive related costs. Therefore, a table of train equipment and traffic statistics is compiled for each of the three route segments studied. They are presented in Tables 3.5 and 3.6. The traffic volume statistics in these tables will be used later with the World Bank Model presented in Chapter IV.

In the Estimation of car days, Hopper and Gondola cars are assumed for unit trains, Box cars for slow freight, Flat cars for fast freight and Hoppers for local trains.

The delay in car days for each type of freight train is calculated by the following formula:

	$CDAY_{ij}$ =	$(NCAR_j * DTHR_{ij})/24$
where	$CDAY_{ij}$ represents	Delay in car days in a year of train type ($_j$) (including inbound and outbound trains) at a given passenger traffic level (i).
	$NCAR_j$ represents	Average number of cars per train type.
	$DTHR_{ij}$ represents	Total annual delay in train hours of train $_j$ at traffic level i.

Similarly, the annual delay in locomotive hours is calculated by multiplying the average number of locomotives per train by the total annual delay in train hours for a given traffic level. As in railway costing, locomotive and associated costs are based on diesel unit miles (DUM), a conversion from locomotive hours to DUM is necessary, and this will be discussed under the unit cost development section in Chapter IV.

The interference delays measured in train hours, locomotive hours and car days for CP and CN rail segments in B.C. are presented in Tables 3.7, and 3.8 respectively.

Table 3.5

TRAIN EQUIPMENT AND TRAFFIC STATISTICS

CN Kamloops - Hydro

Types of Trains	Avg. No. of Cars/Train	Avg. Gross Tons Per Car	Load Factor (%)	Number of LOCOS/TRAIN By Locomotive Power		
				1750	2250	3000
INBOUND						
Locals	96	51	75.4	0	.12	1.78
Fast Freight	76	58	78.9	.02	.07	2.66
Unit/Solid	100	36	7.7	.01	.05	2.45
Slow Freight	100	33	5.1	.02	.07	1.99
OUTBOUND						
Locals	95	80	87.0	0	.08	2.00
Fast Freight	83	77	88.5	.01	.06	2.73
Unit/Solid	99	124	100.0	.01	.03	2.09
Slow Freight	100	98	94.3	.02	.09	1.95

Source : CN 1983 Operating Statistics

Table 3.6

TRAIN EQUIPMENT AND TRAFFIC STATISTICS

CP Kamloops - Mission City

Type of Trains	Avg. No. of Cars/Train	Avg. Gross Tons per Car	Load Factor (%)	Number of LOCOS per Train	Locomotive Horsepower
INBOUND					
Locals	16	51	26.8	2.2	1 750
Fast Freight	61	52	63.4	4.1	3 000
Unit/Solid	103	28	.9	4.2	3 000
Slow Freight	53	53	60.0	3.0	3 000
OUTBOUND					
Locals	9	75	79.1	1.3	1 750
Fast Freight	79	84	89.0	2.9	3 000
Unit/Solid	105	129	100.0	4.9	3 000
Slow Freight	78	107	80.2	3.4	3 000

Source : CP 1983 Operating Statistics

Table 3.7

MEASURES OF INTERFERENCE DELAY
IMPACT OF PASSENGER TRAINS ON FREIGHT OPERATIONS

CN KAMLOOPS-HYDRO

Psg. Trn Per Day	Annual Increase in		Increase in Car Days by Train Type				
	Freight Trn Hrs	Loco Hrs	SL Frt	Unit	Fast Frt	Local	Total
0	-2 103	-4 838	-3 727	-3 848	-844	-44	-8 464
2							
4	2 146	4 935	3 666	4 117	820	43	8 646
6	4 537	10 435	8 114	8 409	1 688	89	18 301
8	7 193	16 544	12 725	13 524	2 621	143	29 014
10	10 078	23 180	18 060	18 640	3 735	201	40 636
12	13 072	30 065	23 396	24 342	4 717	269	52 725
14	16 653	38 301	29 685	31 104	6 038	338	67 165
16	20 501	47 152	36 913	38 205	7 199	418	82 735
18	25 072	57 666	45 019	46 789	8 860	505	101 173
20	30 458	70 053	54 449	57 195	10 683	609	122 936
22	36 541	84 045	65 320	68 587	12 845	729	147 481
24	43 569	100 209	77 728	81 977	15 281	866	175 852
26	51 680	118 864	92 338	97 412	17 869	1 023	208 642
28	61 240	140 852	109 669	115 746	20 705	1 208	247 328
30	72 160	165 968	129 449	136 491	24 095	1 420	291 455
32	89 036	204 783	153 500	170 701	32 942	1 709	358 853
34	119 679	275 261	205 935	228 066	46 119	2 099	482 219
36	166 285	382 456	290 721	308 262	67 675	2 781	669 439

Table 3.8

MEASURES OF INTERFERENCE DELAY
IMPACT OF PASSENGER TRAINS ON FREIGHT TRAIN OPERATION

CP KAMLOOPS-MISSION CITY

	Annual Increase in		Increase in Car Days by Train Type				
Psg. Trn Per Day	Freight Trn Hrs	Loco Hrs	SL Frt	Unit	Fast Frt	Local	Total
0	-1 994	-7 179	-1 844	-3 549	-1 263	-31	-6 687
2							
4	1 915	6 895	1 915	3 683	842	28	6 467
6	4 178	15 039	4 041	7 975	2 051	59	14 126
8	6 500	23 401	6 209	12 420	3 324	92	22 045
10	9 019	32 470	8 587	17 250	4 691	127	30 656
12	11 703	42 131	11 034	22 694	5 964	162	39 853
14	14 864	53 510	14 011	28 750	7 604	204	50 570
16	18 195	65 503	17 089	35 346	9 288	245	61 968
18	22 059	79 414	20 598	43 014	11 255	295	75 162
20	26 540	95 542	24 528	52 062	13 633	347	90 570
22	31 398	113 031	28 736	62 033	16 074	408	107 251
24	36 976	133 113	33 628	73 463	18 883	475	126 450
26	43 120	155 231	38 702	86 737	21 707	546	147 692
28	49 910	179 677	44 333	101 555	24 564	623	171 075
30	58 045	208 963	49 715	118 794	29 256	730	198 495
32	79 387	285 792	69 222	158 175	40 125	1 014	268 536
34	101 084	363 903	85 842	203 316	51 881	1 283	342 322
36	140 707	506 544	118 722	283 616	72 434	1 804	476 577

CHAPTER IV

THE COST OF INTERFERENCE DELAY

This chapter describes the procedures used to estimate the increased cost for freight service due to interference delay. Two approaches are used in the cost estimation. One follows the concepts of railway costing as normally applied in Canada, the other uses the framework of the World Bank Rail Model. CTC Research computer models have been developed for the computation of interference costs. The two methods are presented separately in the following two sections. Section 4.1 deals with the unit cost approach; Section 4.2 presents the World Bank Model method.

4.1 The Railway Unit Cost Approach

This approach involves three steps: firstly, the cost items affected by the train delay are determined; secondly, a set of unit costs related to train delay measurements is developed; and finally, interference costs are calculated by multiplying the quantities of delay time units by the appropriate unit costs.

4.1.1 Cost Items Affected by Train Delay

As discussed in Section 3.2, train delay affects train hours, car days and locomotive hours. In Table 4.1, cost items associated with these delay time units are identified. The impact of train delay on these cost items is discussed below.

Table 4.1

COST ITEMS AFFECTED BY TRAIN DELAY

Train Delay	Cost Items Directly Affected by Train Delay	Cost Items Indirectly Affected by Train Delay	Service Units* Associated with Cost (Railway Costing System)
Train Hours	- Signals, Communication and Train Control, Maintenance, and Ownership	- Overhead	Train hour (CP), Train mile (CN)
	- Crew Wages (long term)		Train hour
Car Days	- Freight Car Maintenance and Ownership	- Shop Machine and Equipment Maintenance and Ownership	Car days
		- Overhead	
Locomotive Hours	- Locomotive Maintenance and Ownership	- Shop Machine and Equipment	Diesel Unit Miles
	- Roadway Maintenance and Ownership	- Overhead	
	- Fuel	- Fuel Station Maintenance and Ownership.	Gallons

*The service or output units are for Directly Affected Cost Items; the unit costs of indirect cost items are normally associated with the expenditure of direct costs.

(1) Signals, Communication and Train Control

Traffic density which is reflected in train delays has a direct effect on the costs of signals and operations. The more meets and overtakes on a particular rail line, the more signal and communication activities are required. In CP costing, the maintenance and ownership costs in this category are related to train hours, and yard and train switching minutes; the part associated with train hours is considered to be affected by train delay. In CN costing, however, costs associated with signals are related to train miles. Thus, the unit cost per train mile has to be converted to a train hour basis. The method of conversion will be discussed in section 4.1.2.

(2) Crew Wages

Crew costs in Canadian railways are computed on a train-run rather than on an hourly basis. In railway practice, train crew wages are calculated by direct analysis from company internal records. However, for unit cost development, the wage rate is usually associated with the gross ton-miles per train run.

The rationale behind this costing method is that, under railway labour contracts, train crew wages are based on mileage subject to a 100-mile minimum, 8 hour day. Thus, any changes within 8 hours (say an increase from 3 to 4 hours in a 100-mile train run), would not affect wages. However, this may be true only in the short run. In the long run, unions negotiate for income levels and would doubtless press for an increase in mileage rates should hours have per train-run rise. Ultimately, it is hourly income that matters.

In this study, the long run effect of train delay on crew wages is taken into account and hourly train crew wages are used to calculate incremental crew costs resulting from interference between trains.

(3) Freight Cars Maintenance and Ownership Costs

Reasons for Order No. R-6313 required that freight train car maintenance costs be considered 25% time related and 75% mileage related, and that freight car ownership costs be considered 80% time related and 20% mileage related. Accordingly, Canadian railways have used car days and car miles separately to develop time and traffic related unit costs for various classes of freight cars.

Train delay results in increases in car days and in the time dependant portion of freight car maintenance and ownership costs. Thus, the unit costs of car days of each type of freight cars are used to calculate freight car related interference costs.

(4) Locomotive Maintenance and Ownership Costs

In the present railway costing system, locomotive maintenance and ownership costs are associated with diesel unit miles.

Train interference does not cause a significant increase in diesel unit miles. However, as in the case of freight cars, a portion (ownership) of locomotive costs is time related. For the purpose of this study, a time-speed conversion factor (section 4.1.2) is used to convert the unit cost of diesel unit miles to locomotive hours.

(5) Fuel

Fuel is one of the direct operating costs that is affected by train interference. An idling train consumes fuel; also, a train consumes much more fuel accelerating than at normal speed. As train meets or overtakes create more instances of train stopping and starting (acceleration and deceleration), incremental fuel costs are incurred. The fuel cost is a function of number of locomotives per train, locomotive powers, transit time, fuel consumption and unit cost. Fuel consumption at delay time can be estimated with two existing models — the AAR and the World Bank models which are presented later in this Chapter.

(6) Shop, Machine and Equipment

The parts of shop, machine and equipment costs related to freight car and locomotive repairs are included in the unit costs of car days and locomotive hours respectively. Specifically, the incremental costs of shop, machine and equipment in train delay are associated with the incremental costs of freight cars and locomotives maintenance.

(7) Overhead

Overheads are general expenses related to administration, labour benefits, property taxes, sales taxes, insurance and other general expense accounts. These expenses are normally associated with the expenditure of direct costs. The part of overheads associated with the unit costs of train hours, car days and diesel unit miles are included in estimating the interference costs.

(8) Fuel Station Maintenance and Ownership Costs

In the railway unit cost method, fuel station expenses are related by regression analysis to fuel costs. In the analysis of interference cost, increased fuel station expenditures are specified as a function of increased fuel costs due to train delay.

4.1.2 The Estimation of Interference Costs

With the unit cost method, interference costs are calculated by multiplying unit costs by service units associated with train delay.

In the traditional railway unit cost development, most operations and maintenance expenditures are related to output units, by either direct analysis or regression analysis. In addition, many of the indirect expenses including administration, supervisory and overhead expenses are related to other sets of expenses. For example, a part of the maintenance of shops and engine houses is explained by freight car maintenance expenses which is, in turn, related to car days and car miles. This process is known as "cost pyramiding". Thus, one work unit may be directly and indirectly linked to a number of expense accounts in the railway system.

For purposes of developing the unit costs for interference analysis, the railway's unit costs build-up procedures are used. In the process of calculating total cost per service unit, detailed cost accounts are involved. For instance, the unit cost per car day may include cost allocations from 44 railway expense accounts. An example of the cost pyramiding method can be found in Hariton (1984). (11)

In estimating interference costs, some distance or other physical units have to be converted to time-related units. These include the conversion from train miles to train hours, from diesel unit miles to locomotive hours and relating gallons of fuel consumption to delay in locomotive hours.

First, an average speed of 12 miles per hour is used to convert distance to hours. This speed is based on an analysis of the train acceleration profile produced by the AAR's Train Performance Calculator and Train Energy Model (12). The speed represents the average train speed during the first 10 minutes after starting of a train, on level track.

Accordingly, the unit costs of train miles and diesel unit miles calculated from costing models are adjusted to unit costs of train and locomotive hours respectively.

The fuel consumption per locomotive hour of delay is determined based on the Energy Report of the AAR model which calculates fuel consumption of a locomotive unit at a given notch position or speed. As train delay in each meet or overtake involves train slow down, speed up and wait time, fuel consumption in interference delay is calculated assuming 25% acceleration time and 75% train idle time. The results show that fuel consumption per locomotive hour of delay is approximately 58% of fuel consumption (in gallons per hour) at normal speed. The unit cost of fuel per locomotive hour is adjusted accordingly for interference cost estimation.

The unit costs developed for estimating the interference costs are presented in Tables 4.2, and 4.3. These unit costs, together with the train delay measures shown in Section 3.2, are used to estimate the impact of passenger train service on the cost of freight operations. The results will be discussed in Chapter V.

4.2 The World Bank RAIL Model

The impact of train delays on railway costs can also be analyzed based on changes in the productivity of rolling stock. The World Bank's RAIL Model is used for this analysis. Section 4.2.1 examines the productivity issue, while section 4.2.2 deals with the additional costs incurred due to reduced productivity of equipment resulting from train delay. The interference cost estimates derived from this approach are presented in Section 5.2.

4.2.1 The Effects of Train Delay on Rolling Stock Requirements and Productivity

Train delay results in longer car and locomotive trip times. Thus, it increases the rolling stock cycle or turnaround time and reduces the annual mileages that can be generated per car and per locomotive. In other words, to carry the same traffic level of ton-miles, more rolling stock is required. The relationships, between average train speed and equipment cycle time, and between cycle times and equipment requirement, can be calculated with the World Bank's RAIL Model. (13)

The RAIL model was designed in the late 1970's to investigate alternative investment policies for developing nations. The RAIL is a large scale and multi-function model by construction. It permits the user to define parameters of eight basic

Table 4.2

ESTIMATED UNIT COSTS FOR INTERFERENCE ANALYSIS
CN KAMLOOPS-HYDRO

Service Unit Affected by Train Delay	Unit Costs ($) Maintenance	Depreciation	Cost of Capital	Total
Train Hours	28.9946	.8114	2.1733	31.9793
Car Days*	.7909	1.1159	4.0981	6.0049
Diesel Unit Hours**	24.8108	2.5603	7.863	35.2341
Fuel Related Costs	.2002	.0076	.033	.2408
Fuel Consumption/ Train Hour	145 Gallons			
Cost per Gallon	$ 1.441			
Crew Wages/Train Hours				
Road Freight Conductor	$ 15.97			
Brakeman	$ 14.71			
Engineer	$ 18.13			
Total	$ 48.81			

*Weighted average of different types of cars.
**Weighted average of different types of locomotives.

Table 4.3

ESTIMATED UNIT COSTS FOR INTERFERENCE ANALYSIS
CP KAMLOOPS-MISSION

Service Unit Affected by Train Delay	Unit Costs ($) Maintenance	Depreciation	Cost of Capital	Total
Train Hours	23.4462	1.1188	3.697	28.262
Car Days*	2.4296	1.4887	4.3955	8.3138
Diesel Unit Hours*	26.3322	3.9343	8.8750	39.1415
Fuel Related Costs	.1755	.0036	.0199	.199
Fuel Consumption/ Train Hour	160 Gallons			
Cost per Gallon	$ 1.503			
Crew Wages/Train Hours				
Road Freight Conductor	$ 17.61			
Brakeman	$ 15.86			
Engineer	$ 22.21			
Total	$ 55.68			

*Weighted average of different types of cars.
**Weighted average of differenty types of locomotives.

ELEMENT types in a railway system. The types of elements are Project, Locomotive, Wagon, Route, Service, Traffic by service/route, Line and Yard. Furthermore, RAIL provides a range of analysis types which represent varying levels of complexity.

RAIL in its original form was considered too redundant for the purpose of this study. Therefore, CTC Research has developed a model which is based on an analysis type at a very aggregate level of the RAIL model called MEXO (for Macro analysis with EXogeneous Operational data). The formats of model inputs and outputs have also been redesigned and simplified to facilitate their use. The model is currently constructed by using the software of LOTUS-123.

Inputs to the models for CN and CP line segments are presented in Tables 4.4 and 4.5 respectively. These inputs are derived from the results of capacity models and data in Tables 3.5 and 3.6. To demonstrate the methodology, the base case and three alternative cases are analyzed. The latter include the case with passenger trains removed, and the cases with 4 and 6 passenger trains per day. It is noted that among the inputs, only two variables, average speed and average transit time, are different in each case.

The model calculates the locomotive and car turnaround times using the following two formulas.

$$LTURN = (TIME + WKDEL + LOCDEL)/24$$

$$CTURN = (TIME + WKDEL + DELSHN + NSHUNT)/24 + CDEL$$

Where LTURN = locomotive turnaround time in days

TIME = average road time over route

WKDEL	=	average working delay
LOCDEL	=	locomotive terminal delay per trip
CTURN	=	car turnaround time in days
DELSHN	=	average delay per shunt
NSHUNT	=	number of shunts en route
CDEL	=	car delays at rail terminals per trip in days

The average road time over a route is affected by train interference delay. In order to measure the effect of train interaction on locomotive and car turnaround times, the other delay components are held constant. Specifically, based on CN and CP 1983 operating data and train schedules, average work program delay and locomotive and car terminal delay are estimated. These delay components are assumed unchanged in the interference analysis.

For the first formula, an average locomotive terminal delay of 40 hours and a work delay of 8 hours are assumed. Thus the total delay for these two components is 2 days.

In the second formula, terminal delay is the most important component affecting car turnaround time. The terminal delay includes car loading and unloading. For the purpose of this study, a terminal delay of 4 days per trip is assumed. Car shunting delay is also a major factor that affects car cycle time; however, it is not affected by train congestion on the main line. A total of 1 day in car shunt and working delay per trip is assumed.

Based on the calculated car and locomotive turnaround times and inputs shown in Tables 4.4 and 4.5, the annual mileage per locomotive (LOCOML) is calculated as:

$$LOCOML = (365/LTURN) * HAUL$$

where HAUL is the average length of haul, and the annual mileage of a car (CARML) is calculated by the formula:

$$CARML = (365/CTURN) * HAUL$$

The requirements for rolling stock are calculated using:

$$LSERV(I) = (NTR/DAYS) * NLOC * LTURN$$

$$LSTOCK(I) = (LSERV(I) * 100) / LAVAIL$$

$$CSERV(I) = (NTR/DAYS) * NTCAR * CTURN$$

$$CSTOCK(I) = (CSERV(I) * 100) / CAVAIL$$

where LSERV (I) = Number of locomotives required in service of Case I

LSTOCK (I) = number of locomotives required in stock

CSERV (I) = number of cars required in service

CSTOCK (I) = number of cars required in stock

NTR = number of train runs in a year

NLOC = number of locomotives per train

LAVAIL = percent of time locomotive available for service

DAYS = number of days per year service operates

NTCAR = number of cars per train

CAVAIL = percent of time car available for service

These statistics, together with other operating statistics calculated by the model, are included in the Rail Operations Report shown in Tables 4.6 and 4.7.

4.2.2 Cost Estimation from the Productivity Approach

Under this approach interference cost is analyzed from the point of view of costs incurred due to reduced productivity. As described in the previous section, train delay increases rolling stock turnaround time, reduces average annual journey and mileages per car and per locomotive, and increases the number of rolling stock units required in service. The method used to investigate the cost implication of these changes is presented in this section.

It is important to note that if, in the system, excess capacity in rolling stock or idled equipment exists, then the interference cost would not be significant. However, in this study, it is assumed that all existing equipment is fully utilized, and new equipment purchases are adjusted to maintain operational capacity. Furthermore, it is assumed that total output levels are not affected by train delay, i.e., the total amount of train miles, locomotive miles and car miles on the specific routes studied would be the same, only additional cars and locomotives have to be brought in as a result of longer cycle times.

The World Bank RAIL Model has built-in mathematical equations to calculate revenues and costs based on route specific cost and traffic data. However, in the model,

Table 4.4

OPERATING STATISTICS - INPUTS

CN KAMLOOPS-HYDRO

DESCRIPTION	INPUTS	PASSENGER TRAINS PER DAY			
		2	0	4	6
System Trackage	ML	227	227	227	227
Length of Haul	ML	227	227	227	227
Annual Traffic	TONS (000)	26591	26591	26591	26591
Average Car Load	TONS	78	78	78	78
Loaded Cars/Train	CARS	54	54	54	54
Empty/Loaded Ratio		0.784	0.784	0.784	0.784
Average Speed	ML/HR	25.65	26.58	24.70	23.74
Average Road Time	HRS	8.85	8.54	9.19	9.56
Locomotives/Train	LOCOS	2.31	2.31	2.31	2.31
Loco. Availability*	%	95	95	95	95
Locomotive Weight	TONS	180	180	180	180
Empty Car Weight	TONS	28	28	28	28
Car Availability*	%	90	90	90	90
	INTERMEDIATE OUTPUTS				
Car Cycle Time	DAYS	9.58	9.55	9.60	9.63
Loco. Cycle Time	DAYS	2.37	2.36	2.38	2.40

*The availability figures in the Table apply to existing equipment only. For new equipment, a 100% availability is assumed.

Table 4.5

OPERATING STATISTICS - INPUTS

CP KAMLOOPS-MISSION

DESCRIPTION	INPUTS	PASSENGER TRAINS PER DAY			
		2	0	4	6
System Trackage	ML	209	209	209	209
Av. Length of Haul	ML	209	209	209	209
Annual Traffic	TONS (000)	29661	29661	29661	29661
Average Car Load	TONS	78	78	78	78
Loaded Cars/Train	CARS	48.5	48.5	48.5	48.5
Empty/Loaded Ratio		0.585	0.585	0.585	0.585
Average Speed	ML/HR	26.16	27.03	25.38	24.52
Road Time	HRS	7.99	7.73	8.23	8.52
Locomotives/Train	LOCOS	3.6	3.6	3.6	3.6
Loco. Availability*	%	95	95	95	95
Loco Weight	TONS	180	180	180	180
Empty Car Weight	TONS	28	28	28	28
Car Availability*	%	90	90	90	90
	INTERMEDIATE OUTPUTS				
Car Cycle Time	DAYS	8.45	8.44	8.47	8.49
Loco Cycle Time	DAYS	2.33	2.32	2.34	2.36

*The availability figures in the Table apply to existing equipment only. For new equipment, a 100% availability is assumed.

Table 4.6

FREIGHT OPERATION REPORT

CN KAMLOOPS-HYDRO FREIGHT

DESCRIPTION	PASSENGER TRAINS PER DAY			
	2 (Base Case)	0	4	6
Number of Trains	6313	6313	6313	6313
Locomotive Miles (000)	3310	3310	3310	3310
Train Miles (000)	1433	1433	1433	1433
Net Ton Miles (000)	6036157	6036157	6036157	6036157
Gross Ton Miles (000)	10497651	10497651	10497651	10497651
Car Miles (000)	138058	138058	138058	138058
Equipment Required in Service				
Locomotives	94.6	94.1	95.2	95.8
Freight Cars	8945.7	8924.2	8969.3	8995.0
Equipment Required in Stock				
Locomotives	99.6	99.1	100.2	100.8
Freight Cars	9939.7	9918.2	9963.3	9989.0
Increase in Rolling Stock Requirement				
Locomotives		-0.52	0.57	1.18
Freight Cars		-21.52	23.61	49.29
Annual Miles per Locomotive	34978	35170	34770	34546
Annual Miles per Car	15433	15470	15392	15348
GTM/Locomotive	6296106	6330626	6258674	6218443
GTM/Car	1106873	1109542	1103959	1100807
Train Hours	55871	53914	58018	60354

Table 4.7

FREIGHT OPERATION REPORT

CP KAMLOOPS-MISSION

DESCRIPTION	PASSENGER TRAINS PER DAY			
	2 (Base Case)	0	4	6
Number of Trains	7841	7841	7841	7841
Locomotive Miles (000)	5899	5899	5899	5899
Train Miles (000)	1639	1639	1639	1639
Net Ton Miles (000)	6199149	6199149	6199149	6199149
Gross Ton Miles (000)	10788174	10788174	10788174	10788174
Car Miles (000)	125970	125970	125970	125970
Equipment Required in Service				
Locomotives	180.4	179.6	181.2	182.1
Freight Cars	8806.2	8788.6	8823.1	8842.9
Equipment Required in Stock				
Locomotives	189.9	189.1	190.7	191.6
Freight Cars	9784.7	9767.1	9801.5	9821.4
Increase in Rolling Stock Requirement				
Locomotives		-0.83	0.79	1.72
Freight Cars		-17.65	16.82	36.69
Annual Miles per Road Locomotive	32700	32850	82558	32391
Annual Miles per Car	14305	14333	14277	14245
GTM/Locomotive	5885946	5913035	5860354	5830411
GTM/Car	1104478	1106696	1102372	1099895
Train Hours	62642	60631	64560	66824

all cost inputs are first converted to unit cost per net ton-mile. These formulae can not be used directly for interference cost analysis. Nevertheless, the model links the maintenance and capital charges to the equipment requirements. Thus, with some modification, the concept of the model is used wherever possible in the estimation of interference cost.

As for the unit cost approach, the interference cost model presented here depends heavily on how costs are identified and allocated. For purposes of cost allocations, data from the 1983 Statistics Canada Report 52-215, Railway Financial and Traffic Statistics are used. (14) In Tables 4.8 and 4.9, cost components developed from CN and CP operating expenses are presented. In these tables, the units given form the basis on which costs are calculated. Costs are classified as either variable with traffic or fixed on an annual basis. The cost components are calculated using the method adopted in the paper by Petersen, Taylor and McLaren entitled "Western Canada: A Case Study in Rail Modelling". (15)

Four major cost groups are identified for the interference analysis; they are rail operation costs, maintenance costs, depreciation and capital charges. With the cost components listed in Tables 4.8 and 4.9, the model calculates interference costs by the equations outlined below.

(1) Rail Operation Costs

In the World Bank's Line model, line haul costs are broken down into crew wages, fuel and oil. The crew labour cost is assumed to be distance rather than time related. Oil cost is estimated as a percentage of the fuel cost. Only the equation used

Table 4.8

COST DATA

CN KAMLOOPS-HYDRO

COST COMPONENTS	VAR OR FX	UNIT	COSTS $
Crew	V	Trn-HR	48.81
Fuel	V	Trn-HR	208
Other Rail Operation	V	GTM	0.0015
Maintenance			
Locomotive	V	Loco-ML	1.3534
	F	Annual/Loco	79838
Freight Car	V	Car-ML	0.0750
	F	Annual/Car	807
Way and Structure	V	GTM	0.0014
	F	Annual/ML	4123
Depreciation			
Locomotive	V	Loco-ML	0.7153
Freight Car	V	Car-ML	0.0219
Way and Structure	V	GTM	0.0007
Capital Charges			
Loco	V	Locomotive	10%
Wagon	V	Car	10%
Way and Structure	V	ML	10%

Table 4.9

COST DATA

CP KAMLOOPS-MISSION

COST COMPONENTS	VAR OR FX	UNIT	COSTS $
Crew	V	Trn-HR	55.68
Fuel	V	Trn-HR	238
Other Rail Costs	V	GTM	0.0012
Maintenance			
Locomotive	V	Loco-ML	1.215
	F	Annual/Loco	84610
Freight Car	V	Car-ML	0.0779
	F	Annual/Car	940
Way and Structure	V	GTM	0.0019
	F	Annual/ML	3186
Depreciation			
Locomotive	V	Loco-ML	0.5747
Freight Car	V	Car-ML	0.03
Way and Structure	V	GTM	0.0005
Capital Charges			
Locomotive	V	Locomotive	10%
Freight Car	V	Car	10%
Way and Structure	V	ML	10%

to calculate fuel cost per train is of interest in estimating inteference delay cost; it is specified as:

FUEL C (I) = FCON * FCOST * HORSEP * NLOC *
((.15 + .85 * AVSPD (I)/MXSPD) * FRTIME + .15 * (WAIT (I)/60 -FRTIME +
.25 * LOCDEL))

A detailed description of this equation and its variables can be found in reference. (12) Essentially, this equation specifies fuel cost per train as a function of the free running time (FRTIME), train speeds (AVSPD and MXSPD), road time (WAIT) which includes delays, and other variables related to locomotive characteristics. With some mathematical operations, the equation can be reduced to show that the fuel cost per unit of delay time can be calculated as 15% of the cost for free running time. This ratio is a low estimate compared with the factor of 58% developed in Section 4.1.

In this analysis, crew costs are assumed to change in the long run due to train interference delay. The incremental crew costs are estimated by multiplying hourly crew wages by additional train hours in a year. The incremental fuel costs are calculated by the above specified formula. The fact that this formula gives lower estimates of fuel consumption in delay time than a previously used formula is considered unimportant, because the main purpose of this study is to investigate alternative methods for the estimation of interference costs.

In the railway financial statement (Table A-1 in the Appendix), rail operation costs include train related expenses (which are line haul costs) and nine other cost items. Of the latter, three cost items — yard related expenses, station operation and other transport modes — are excluded from the interference cost analysis, the remaining six

items are summed to form the other rail operating cost group. The unit costs per gross ton-mile for this group are calculated and shown in Tables 4.8 and 4.9. The method of calculating interference cost for this group of expense is outlined below.

First, it is assumed that total annual gross ton miles are not affected by interference delay, only the requirement for new rolling stock. Thus:

$$(1)\ GTM = GTM_{oj} + GTM_{nj}$$

where GTM is annual gross ton miles, GTM_{oj} represent the GTM carried by existing equipment (including cars and locomotives) and GTM_{nj} represents the GTM carried by added equipment at a given traffic level j. In the base case:

$$GTM = GTM_{oj} \text{ and } GTM_{nj} = 0.$$

the unit cost per gross ton-mile for a given traffic level is adjusted as:

$$RCGTM_j = RCGTM_o * (GTM/GTM_{oj})$$

where $RCGTM_j$ and $RCGTM_o$ represent rail operation costs per GTM at traffic level j and the base case o respectively. The interference cost is calculated as:

$$IRC = (RCGTM_j - RCGTM_o) * GTM = RCGTM_j * GTM_{nj}$$

where IRC represents the incremental railway operating cost.

(2) Maintenance Costs

In the World Bank Model, maintenance costs for rolling stock are specified as a combination of fixed annual cost per unit plus per mile travelled. Rolling stock maintenance costs are calculated as:

$$LOCOM = NLOCO * LFCOST + NLOCO * DUM * LVCOST$$

$$CARM = NCAR * CFCOST + NCAR * CM * CVCOST$$

The interference delay costs are calculated as:

$$LDELC = NLOCO_{nj} * LFCOST$$

$$CDELC = NCAR_{nj} * CFCOST$$

Where

LDELC	=	incremental cost of locomotive maintenance due to interference delay
$NLOCO_{nj}$	=	number of new locomotives required at traffic level j.
LFCOST	=	annual fixed cost per locomotive
CDELC	=	incremental cost of car maintenance due to interference delay
$NCAR_{nj}$	=	number of new cars required at traffic level j
CFCOST	=	annual fixed cost per car

(3) Depreciation Costs

In this analysis, depreciation is calculated on rolling stock usage and replacement value. Thus, the delay induced increases in equipment depreciation are:

DEPLOC = $LOCOML_j$* $NLOCO_{nj}$ * LCOST/LLIFE

DEPCAR = $CARML_j$* $NCAR_{nj}$ * CCOST/CLIFE

where DEPLOC = incremental locomotive depreciation cost

$LOCOML_j$ = annual miles per locomotive at traffic level j

LCOST = the replacement cost of locomotive

LLIFE = the locomotive life in miles

DEPCAR = incremental car depreciation cost

$CARML_j$ = annual miles per car at traffic level j

CCOST = the replacement cost of freight cars

CLIFE = freight car life in miles

(4) Capital Charges

Capital charges are defined as the opportunity cost of the undepreciated capital invested in rolling stock, way and structure. Capital charges for the rolling stock are:

CAPLOC = NLOCO * LCOST * RATE/730

CAPCAR = NCAR * CCOST * RATE/730

Where the annual capital charge is the average book value (equal to half the replacement value) times the required rate of return. The interference costs are calculated based on new equipment requirements.

CHAPTER V

EVALUATION OF THE COST MODELS AND ESTIMATES

This chapter includes three sections. The first two analyze separately the inteference cost estimates obtained from the unit cost and productivity models; the third evaluates and compares the methodologies and results of the two models.

5.1 Results of the Unit Cost Model

For each rail segment, results of the unit cost model are summarized in two tables. The first table shows the total interference cost and breakdowns by five cost groups. They are signals and communication, locomotive and roadway, freight cars, fuel and crew wage. In the second table, the costs of the first three groups are further disaggregated into maintenance, depreciation and cost of capital. The results for the CN segment are shown in Tables 5.1 and 5.2, and those for the CP segment are shown in Tables 5.3 and 5.4.

As shown in these tables, passenger trains are incremented from 0 to 12 per day. As mentioned earlier in Section 3.1, the twelve-trains per day limit (6 in each direction) is based on capacity analysis. The case with 0 passenger trains can be interpreted from two points of view. On the one hand, it represents the interference cost that can be saved by removing the passenger trains. On the other hand, it represents the hidden cost borne by the freight service because of the existence of the passenger train runs.

Table 5.1

INTERFERENCE COSTS

CN KAMPLOOPS-HYDRO

1983

(dollars)

Passenger Trains/Day	Signal & Communication	Loco Roadway	Freight Cars	Fuel	Crew Wages	Total
0	-67266	-170460	-50824	-253760	-102669	-644979
2						
4	68620	173891	51874	258867	104736	657988
6	145092	367680	109899	547357	221457	1391485
8	230027	582916	174183	867773	351094	2205992
10	322298	816743	244029	1215867	491930	3090868
12	418022	1059318	316598	1576982	638035	4008955

Table 5.2

INTERFERENCE COST BREAK-DOWNS BY MAINTENANCE AND OWNERSHIP COSTS

CN KAMLOOPS-HYDRO

1983

(dollars)

Passenger Trains/Day	Signal & Communication			Loco and Roadway			Freight Cars		
	Maintenance	Dep.	CoC.	Maintenance	Dep.	CoC.	Maintenance	Dep.	CoC.
0	-60988	-1707	-4571	-120033	-12386	-38041	-6694	-9445	-34685
2									
4	62214	1741	4663	122449	12636	38806	6662	9703	35510
6	131551	3682	9860	258910	26717	82053	14553	20415	74931
8	208558	5837	15631	410472	42357	130086	22899	32419	118864
10	292218	8178	21902	575127	59348	182268	32369	45314	166346
12	379008	10607	28407	745941	76975	236402	41960	58819	214819

Table 5.3

INTERFERENCE COSTS

CP KAMLOOPS-MISSION CITY

1983

(dollars)

Passenger Trains/Day	Signal & Communication	Loco & Roadway	Freight Cars	Fuel	Crew Wages	Total
0	-56358	-280990	-55596	-275303	-111032	-779279
2						
4	54132	269892	53381	264430	106647	748483
6	118068	588664	116838	576750	232609	1632929
8	183707	915933	182487	897395	361929	2541451
10	254909	1270930	253842	1245207	502205	3527092
12	330754	1649083	329933	1615706	651631	4577107

Table 5.4

INTERFERENCE COST BREAK-DOWNS BY MAINTENANCE AND OWNERSHIP COSTS

CP KAMLOOPS-MISSION CITY

1983

(dollars)

Passenger Trains/Day	Signal & Communication			Loco and Roadway			Freight Cars		
	Maintenance	Dep.	CoC.	Maintenance	Dep.	CoC.	Maintenance	Dep.	CoC.
0	-46754	-2231	-7372	-189034	-28244	-63712	-16247	-9956	-29394
2									
4	44908	2143	7081	181568	27128	61196	15706	9531	28144
6	97949	4674	15445	396020	59170	133474	34310	20879	61649
8	152404	7272	24031	616188	92065	207679	53548	32621	96319
10	211473	10091	33345	855010	127748	288171	74464	45382	133996
12	274394	13093	43267	1109411	165758	373914	96804	58981	174149

With the unit cost approach, the interference costs are directly related to train delay time units. Since the relationship between average freight train delay and incrementing number of passenger trains per day is non-linear. The cost curves obtained from the interference analysis also show greater incremental costs at higher traffic levels. The total interference cost curves for CN and CP rail segments are depicted in Figure 5.1.

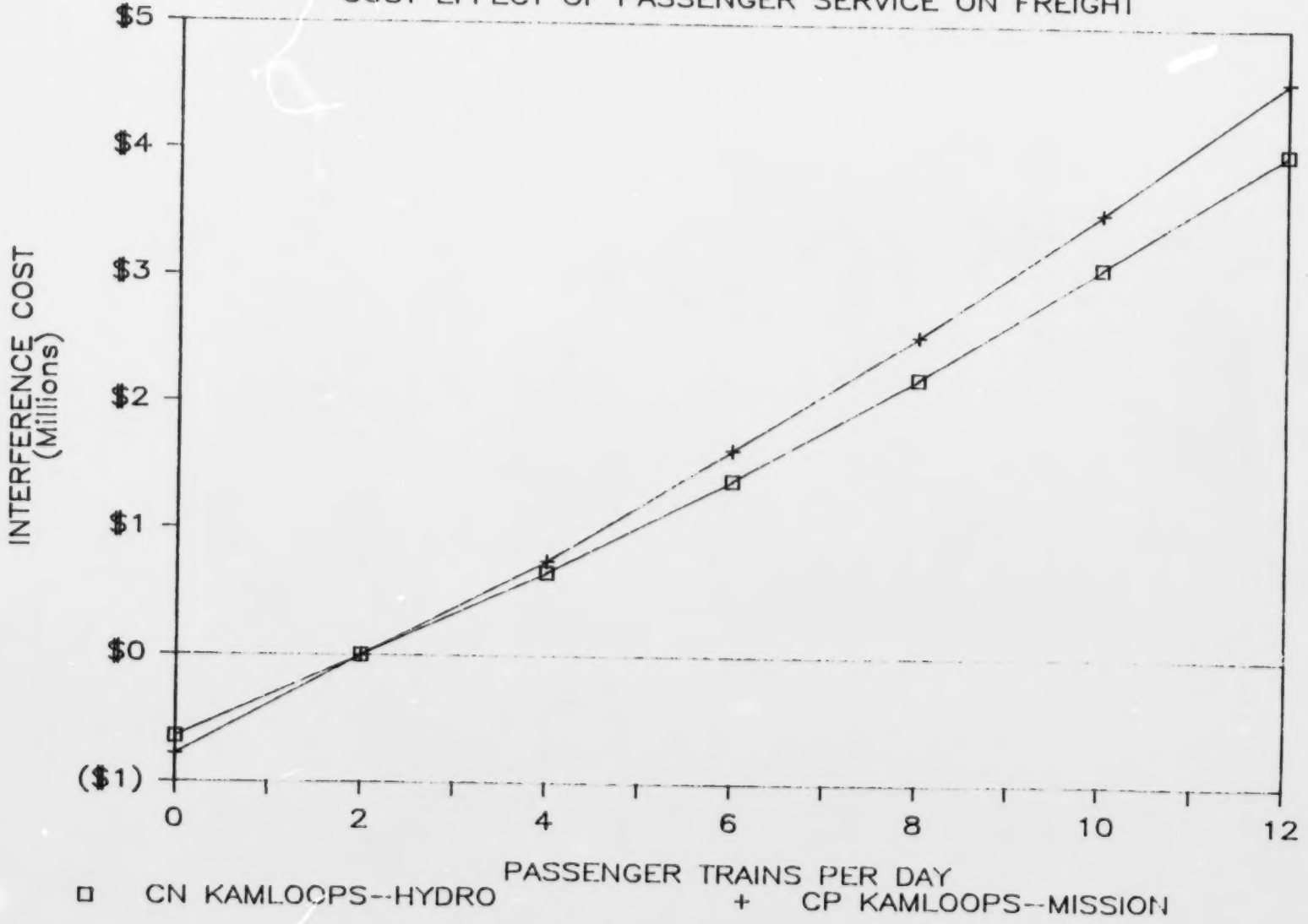
This Figure shows that the CP cost curve is steeper than the CN curve. This may be attributed to several factors: First, on the average, there are more locomotives per train on the CP line. Thus, for each hour of train delay, locomotive related interference cost is higher for CP than for CN. Second, the average maintenance cost for CP freight cars is higher than CN's. Finally, the same is true with the linehaul cost including both crew and fuel costs. Overall, the unit costs related to interference delays are higher in CP than for CN.

Among the cost items, fuel contributed most to the total interference cost. It represents 39 and 35 percents in CN and CP cases respectively. The second largest cost group is maintenance and ownership costs related to locomotive hours. As shown in Tables 5.2 and 5.4, maintenance cost is more important than ownership costs in train and locomotive hours related cost items. However, the reverse is true in car-day related costs.

In order to assess the reasonableness of the cost estimates, they are compared to the estimated indirect cost charged by railways to VIA. This involves several steps. First, annual passenger train miles on the Kamloops-Hydro route are compared to total CN operated passenger train miles to derive a percentage of traffic.

FIGURE 5.1

COST EFFECT OF PASSENGER SERVICE ON FREIGHT



CN data is used because Statcan data for CP does not show passenger traffic. Second, this percentage is applied to the estimated total railway indirect cost shared by VIA to estimate the cost share of the rail segments studied. Third, total interference costs calculated for CN and CP are summed. Finally, the total interference cost is compared with the estimated passenger service's share of railway indirect cost. The calculations are illustrated in Table 5.5.

The results show that the estimated passenger service's share of the indirect cost in the area studied is around $2 million, while the total interference cost calculated here amounted to $1.4 million. These two figures are surprisingly close.

5.2 Results of the Productivity Approach

Under this approach, train delay times are built into equipment cycle times and the incremental costs associated with the resulted new equipment requirement are calculated. The costing procedures used in this method have already been discussed in Section 4.2. The results of interference costs for CN and CP rail segments are presented in Tables 5.6 and 5.7 respectively.

In these two tables, the cost effect of interference delay is estimated for each cost group in a railway income statement (as shown in Appendix) with the exception of the general expense items. The cost groups include rail operation cost, way and structure and rolling stock maintenance and depreciation costs. In addition, the cost of capital of new rolling stock is estimated.

The general expense group (excluding benefits which have been allocated to other cost groups) are not included in this interference cost analysis for two reasons.

Table 5.5

COMPARISONS OF TOTAL INTERFERENCE COST WITH THE PASSENGER SERVICE'S SHARE OF RAILWAY INDIRECT COST

1983 Costs

(KAMLOOPS AREA)

1. Total railways' charge to VIA in 1983 = $379 million

2. Estimated Indirect Cost (30% of total cost) = $114 million

3. Total CN passenger train miles in 1983 = 9,339,332

   CN Kamloops-Hydro annual passenger traffic = 165,710 train miles
   (Length of haul x 2 trains per day x 365)

   Traffic studied compared to total = 1.8%

4. Passenger services' share of railway indirect cost on the routes studied is estimated as:

   $114 million x .018 = $2 million

5. Total Interference Cost = $664,979 + $779,279 = $1.4 million

Sources:
(1) VIA Annual Report 1983.
(2) Table 1b, StatCan 52-215.
(3) Tables 5.1 and 5.3 of this study.

First, it is still debatable whether this cost group should be included in the interference cost analysis, and second, it would require further analysis to develop functional relationships between the overheads and the interference delay.

Consequently, the total interference costs presented in Tables 5.6 and 5.7 are lower than those estimated under the unit cost approach. However, the lower cost estimates are also, in some cases, attributable to the different mathematical equations adopted in the two approaches. In particular, fuel costs estimated in the previous section are about three times higher than those presented here; this is due to the use of different fuel consumption formulae rather than the unit cost of fuel, i.e. cost per gallon.

In the case of the removal of passenger trains, the total savings to the two railways in the region studied would be $831,239 which is around 58 per cent of the estimate of the unit cost approach and about 42 per cent of the estimated passenger service's share of indirect cost in the railway subdivisions studied.

5.3 Evaluation of the Cost Models

The preliminary modelling effort made in this study indicates the feasibility of estimating the interfernce cost for individual train services. However, the *status quo* of both the unit cost and rolling stock productivity models is imperfect; both models need refinements in order to enhance the applicability of the interference cost approach in railway costing. The advantages, deficiencies and required future work of these models are discussed below.

Table 5.6

RAIL MODEL

INTERFERENCE COSTS

CN KAMLOOPS-HYDRO

1983

(dollars)

	Remove Passenger Trains	Add Two Passenger Trains	Add Four Passenger Trains
RAIL OPERATING COST			
Crew	-95525	104769	218783
Fuel	-61061	66970	139849
Other	-40517	44646	93476
MAINTENANCE			
Locomotive	-41203	45190	94367
Freight Car	-17369	19049	39780
Way & Structure	-37920	41784	87484
DEPRECIATION			
Locomotive	-12983	14078	29209
Freight Car	-7307	7974	16604
Way & Structure	-10238	11163	23235
CAPITAL CHARGES			
Locomotive	-25804	28301	59099
Freight Car	-32284	35408	73940
TOTAL	-382210	419333	875826

Table 5.7

RAIL MODEL

INTERFERENCE COSTS

CP KAMLOOPS-MISSION

1983

(dollars)

	Remove Passenger Trains	Add Two Passenger Trains	Add Four Passenger Trains
RAIL OPERATION COSTS			
Crew	-111979	106740	232820
Fuel	-71797	68438	149276
Other	-29423	28137	61486
MAINTENANCE			
Locomotive	-69929	66657	145392
Freight Car	-16589	15813	34492
Way & Structure	-46602	44566	97385
DEPRECIATION			
Locomotive	-15604	14741	31989
Freight Car	-7589	7205	15681
Way & Structure	-11721	11118	24181
CAPITAL CHARGES			
Locomotive	-41324	39391	85919
Freight Car	-26473	25234	55040
TOTAL	-449029	428041	933661

Firstly, the advantage of the unit cost approach is that the "pyramiding" unit cost method provides a link between train delays and the cost items directly and indirectly affected by the delays. The major deficiency of this approach is that most of the unit costs currently adopted by the railways were developed with the passenger service included. Thus, to develop more precise interference costs it would be necessary to review and reconstruct the regression-based unit costs in the railway costing system.

Secondly, the World Bank's RAIL Model is found very useful in analyzing the effect of interference delay on rolling stock requirement and productivity. Also, the sample model developed with this approach suggests that it is possible to use aggregated railway data to estimate interference costs. However, the model is a preliminary construction. The validity of the equations used for estimating interference cost relating to way and structure, and other railway operations costs has to be further examined. Use of the railway costing system would be helpful but such results unpublishable. Furthermore, general administration and other overhead items are excluded from the model; this requires further study.

Finally, in comparing the two cost models, the productivity approach is found useful in the estimation of interference costs associated with rolling stock, while the unit cost approach is favoured for train operation and indirect costs. In fact, these two models can be redesigned to accommodate each other.

CHAPTER VI

CONCLUSIONS

The concept and reality of train interference cost has been understood for some time. It is clearly an aspect of importance to a railway for its internal investment evaluation and traffic development decision purposes. From the governmental (regulatory) perspective it has not been relevant. However, the separation of the passenger service from the freight railways, and particularly the present railway passenger policy as typified by Bill C-97, has placed an increased focus on short run avoidable cost, and allowed for flexibility in the negotiation of payments to the railways. Alternative approaches to the determination of cost have become more relevant.

The cost estimates developed in the course of this study are not included as conclusions. The figures are not the most accurate possible. They were developed for purposes of illustration using non-confidential data. They do, however, allow two important conclusions:

1. Defensible interference cost estimates are possible.

2. Projected to the total system, the sums concerned run to several tens of millions of dollars.

A comparison of the above estimates with current payments to cover indirect costs also allows a further conclusion; VIA and governments are much more likely to pursue this line of enquiry than are the host (freight) railway companies.

It remains to emphasize that this study is a research project in a very strict sense. Pratical implementation of the methodology developed and illustrated here will require substantial further work. However, such is not the logical next phase. Feasibility has been established, the topic must now be addressed in a policy content. Then further development effort presumably by railway costing specialists will be warranted.

APPENDIX

TABLE A-1

RAILWAY OPERATING REVENUES AND EXPENSES, YEAR ENDED DECEMBER 31, 1983

No.	Item	Canadian National	Canadian Pacific
1.	Freight Revenue	2,748,421	2,059,232
2.	Passenger Revenue	654	(1)
3.	Miscellaneous Rail Revenue	65,694	70,075
4.	Revenue from Services for VIA	315,193	68,723
5.	Government Payments	283,058	220,699
6.	Total Operating Revenue (Rail)	3,413,020	2,418,728
7.	Non-rail and Miscellaneous Revenue	9,345	681
8.	TOTAL REVENUE	3,422,365	2,419,409
	Expenses		
	Way and Structure:		
9.	Administration	65,823	41,108
10.	Track and Roadway - Maintenance	266,457	200,583
11.	Track and Roadway - Depreciation	66,592	39,455
12.	Buildings - Maintenance	41,052	22,055
13.	Buildings - Depreciation	17,692	10,045
14.	Leasehold Improvements - Amortization	-	-
15.	Signals, Communications and Power - Maintenance	8,290	33,015
16.	Signals, Communications and Power - Depreciation	3,784	2,211
17.	Terminals and Fuel Stations - Maintenance	3,784	2,211
18.	Terminals and Fuel Stations - Depreciation	902	1,652
19.	Miscellaneous Way and Structures Expenses	26,468	2,990
20	Special Depreciation	(3,370)	(746)
21	Sub-total	537,305	356,416
	Equipment:		
22.	Administration	26,939	21,694
23.	Locomotives - Maintenance and Servicing	238,902	155,981
24.	Locomotives - Depreciation	21,582	21,856
25.	Freight Cars - Maintenance	193,161	145,422
26.	Freight Cars - Depreciation	26,216	23,759
27.	Passenger Cars - Maintenance and Servicing	70,061	10,578
28.	Passenger Cars - Depreciation	-	-
29.	Intermodal Equipment - Maintenance	12,941	3,700
30.	Intermodal Equipment - Depreciation	4,570	3,507
31.	Work Equipment and Roadway Machines - Maintenance	51,161	36,892
32.	Work Equipment and Roadway Machines - Depreciation	14,911	7,556
33.	Other Equipmment - Maintenance	232	
34.	Other Equipment - Depreciation	6,833	2,680
35.	Equipment Rents (Net)	110,251	50,009
36.	Miscellaneous Equipment Expenses	33,195	26,204
37.	Special Depreciation	(76)	(15)
38.	Sub-Total	810,879	509,823
	Rail Operation:		
39.	Administration	48,662	39,932
40.	Train Related Expenses	517,196	409,446
41.	Yard Related Expenses	123,913	117,140
42.	Train Control	39,254	22,666
43.	Station and Terminal Operation	99,521	61,872
44.	Other Rail Operations	41,523	14,568
45.	Other Transport Modes	68,286	34,571
46.	Equipment Cleaning and Specialized Servicing	49,684	23,323
47.	Casualties and Claims	34,514	26,493
48.	Miscellaneous Operating Expense	44,105	12,530
49.	Sub-Total	1,066,658	762,541

...cont'd.

TABLE A.1

RAILWAY OPERATING REVENUES AND EXPENSES, YEAR ENDED DECEMBER 31, 1983 (concluded)

No.	Item	Canadian National	Canadian Pacific
General:			
1.	Administration	257,131	157,313
2.	Employee Benefits	214,181	157,151
3.	Taxes - Other than on Income	86,793	63,398
4.	Other General Expenses	25,594	9,249
5.	Sub-Total	583,699	387,111
6.	Other	210,451	49,483
7.	Total Expenses	3,208,992	2,056,374
8.	Non-Rail Expenses	12,242	-
9.	TOTAL EXPENSES	3,221,234	2,056,374
10.	Income Before Income Taxes and Extraordinary Items	201,131	363,035
11.	Income Taxes	-	179,065
12.	Net Income Before Extraordinary Items	201,131	183,970
13.	Extraordinary Items	-	-
14.	Net Income for the Year	201,131	183,970

Source: Table 1, Statcan Catalogue 52-215.

REFERENCES

1. English, G.W. and C. Schwier (1986) "User Analyst Guide CIGGT Linemodel V 2.1", Canadian Intitute of Guided Ground Transport, Queen's University, Kingston.

2. Spector, A.N., "An Assessment of Railway Line Capacity Models Available to the CTC", Research Branch, Canadian Transport Commission, 1986.

3. Petersen, E.R., "Interference Delays on a Partially Double-Tracked Railway with Intermediate Signalling", Transport Research Forum, Vol. 16, No. 1, 1975.

4. Delcan, Deleuw Cather, Canada Ltd., "Joint Track Usage Study, Kamloops-Mission, B.C.", Report No. 32-1727, November 1985.

5. Spector, A.N. (1986), op. cit.

6. Canadian Transport Commission, "Railway Costing Study", Phase I Report, October 1978; Phase II Report, Volumes 1-5, October 1979.

7. Hariton, G., "Railway Costing - A Review", Research Branch, Canadian Transport Commission, WP 60-84-04, 1984.

8. VIA Rail Canada, Annual Report 1983.

9. Kieran, M.E. and J.M. Mugnet, "Passenger Trains and Rail Traffic Interference", Peat, Marwick and Partners, paper presented at RTAC Annual Meeting, Vancouver, Oct. 1977.

10. Spector, A.N. "An Economic Evaluation of Capacity Issues in the Potential Joint Track Usage Territory between Kamloops and Mission City, British Columbia", Research Branch, Canadian Transport Commission, 1987.

11. Hariton, G., op. cit. in 6.

12. A.A.R. "The Performance Calculator and Train Energy Model" (AAR undated).

13. Taborga, P.N., "Railway Analysis Interactive Language RAIL User's Manual", The World Bank, March, 1985.

14. Statistics Canada, "Railway Transport in Canada - General Statistics", Cat. 52-215, 1983.

15. Petersen, E.R., A.J. Taylor and M.L. McLaren, "Western Canada - A Case Study in Rail Modelling", CTRF, May 1986.

16. Hay, W.W., "Railroad Engineering", Second Edition, John, Wiley & Sons, 1982.

17. Peat, Marwick and Partners, "Passenger Service Costing, Cost Analysis - Indirect Costs", a report to Transport Canada, July 1977.

18. Khan, A.M., "Railway Capacity Analysis and Related Methodology", Research Branch, Canadian Transport Commmission, 1979.